Study of Overall Equipment Effectiveness of Manufacturing System

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Abstract:

Overall equipment effectiveness is one performance metric that communicates current production condition with the fewest calculations. With the use of measurement and corrective actions, losses can be minimized. The effective use of personnel, equipment, resources, and techniques will result in increased productivity. The overall equipment effectiveness (OEE) statistic is created by the combination of availability (A), performance rate (PR), and quality rate (QR). When an increase in production is predicted, the equipment that converts a product from its unfinished state into completed goods must be dependable. If the chosen machine tool's mean time between failures (MTBF) is higher, it indicates that the machine tool is available for the specified performance. The mean time to repair (MTTR) must be reduced, and the mean time between failures (MTBF) must be increased. Root cause analysis and failure data analysis are required. Using the failure information that has been gathered, we may determine the equipment's availability (A). Manufacturers can improve the functionality of their equipment, how it is operated, and how it is maintained by installing a system that can measure and analyse. The main objective of any OEE programme is to increase effectiveness and efficiency.
a producer using the market to cut losses. OEE standards between 85% and 90% are regarded as world-class. However, maintaining a grade of 85% alone does not guarantee world-class position. Performance levels for each OEE component must vary; for example, quality should be 99%, performance should be 95%, and availability should be 90%. By using them as a point of comparison, manufacturers can use these benchmarks to evaluate when these components meet acceptable levels. OEE measures enable proactive decisions based on throughput, efficiency, effectiveness, and process bottleneck constraint studies instead of reactive maintenance decisions based on breakdown reports and product production decisions based on plant schedules.

Key words: *Quality Rate, Overall Equipment Effectiveness, Performance Rate, process bottleneck*

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1. INTRODUCTION

Monitoring and enhancing manufacturing process efficiency is done by measuring overall equipment

effectiveness (OEE). OEE is now a widely used management technique for assessing and monitoring factory floor productivity. The three measuring parameters for OEE are availability, performance, and quality. OEE highlights an organization's true "Hidden capability." OEE is not the only indicator of how efficiently the maintenance department operates. The OEE is impacted by the equipment's design, installation, use, and maintenance. It assesses both effectiveness (performing the proper thing) and efficiency (using the equipment correctly). OEE is calculated by multiplying the product of the rate of high-quality product production, process performance efficiency, and equipment availability. OEE therefore depends on the three variables listed below.

A. Availability

This can be clear as uptime, i.e., when the equipment is accessible to work.

B. Performance

This is the quickness at which the manufacturing unit functions as a % term of the capability of the unit.

C. Quality

This is frequently denoted to as being FPY, which is the First Pass Yield and is the number of good i.e., flawless objects that are formed with no defects.

OEE (Overall Equipment Effectiveness) considers availability along with performance rate and quality rate. To put it another way, OEE addresses all losses caused by the equipment's inability to operate at its peak due to reduced speed, idling, and minor stoppage losses, as well as its inability to be available when needed due to breakdowns or set-up and adjustment losses and its inability to produce first-pass quality output due to flaws and rework or start-up losses. Figure shows a simple model that describes these losses.

Using a plant OEE analysis starts with time, or the length of time your facility is open and prepared for equipment use.
Add the category of time known as Planned Shut Down, which includes all occurrences that should be excluded from efficiency analysis since production was not planned to continue, to Plant Operating Time (e.g., breaks, lunch, scheduled maintenance, or periods where there is nothing to produce). The time that is still available is your planned production time.
OEE evaluates productivity and efficiency losses that occur with the goal of reducing or eliminating them. It begins with the intended production time. Three types of losses can be distinguished: downtime losses, speed losses, and quality losses.
Down Time Loss, which includes any Events that stop planned production for a significant amount of time, is taken into account when determining availability. For instance, equipment failures, a supply shortage, and transitional stages. Operating Time is the remaining amount of time.
Performance measures a process's efficiency by accounting for Speed Loss, or any variables that prohibit it from working at maximum speed. Ineffective operators, inferior materials, inappropriate feeds, and machine damage are a few examples. The amount of time that is still available is known as Net Operating Time.

2. LITERATURE SURVEY

Atul Pandey, Susheel Malviya et. al.[1] examined the production facility and assessed TPM implementation problems as well as the advantages of OEE that came from TPM implementation. It is clear that OEE on the boiler plant has increased steadily, which is a sign of higher equipment availability, lower rework and rejection rates, and higher performance rates. As a result, the industry's overall productivity rose as well. The OEE value is encouraging, and over time, the results will be quite strong, maybe reaching an OEE value of 85% to 90% that is on par with the best in the world.
Sivakumar Annamalai, D. Suresh [2] found a significant difference between the calculated and actual OEEs. With the addition of the term "yield," which accurately depicts the industry's use of materials, the measured OEE is further reduced. Unskilled labour, bad maintenance, inappropriate cleaning, continuous operation, etc. are some of the key culprits, according to an analysis of all the elements relevant to this significant deviation of OEE.
Rohan R. Sanger, Dr. N.H.Deshpande [3] suggested Overall Equipment Effectiveness (OEE) is the important tool of Lean Manufacturing. OEE gives exact efficiency of the machines .The improvement of the efficiency it depends on the actual machine condition. Lean manufacturing is widely necessary for the growth of the industry is all areas. OEE can be increased by reducing the losses like no load, no operator, and setup time reduction. OEE does not monitor the equipment, but show the status of equipment to take corrective action for better improvement.
Daniel DreherSilveira[4] looked at overall equipment effectiveness (OEE), a tool for managing and continuously improving the manufacturing process that can help discover losses and cut down on production expenses. The operation manager must decide how to minimise or reduce process losses by examining the findings of this indicator.
Surya Paraná, Evan Haviana [5] observed machine's productivity decrease due to the following main four factors such as less operator knowledge about the machine (Human), unstable glue temperature (Machine), late vendor supply (Material), and inefficient knife replacement time (Method). After working on the improvement referring to above root causes and further calculation using the Overall Equipment Effectiveness (OEE) method, the general achievement of OEE has increased around 6% although not yet reached the World Class OEE standard.
M. Singh and M. Narwal [6] focused on the manufacturing sector, and many lines of work examine OEE concepts (assembly, housing, pinion etc.). For this, the three factors of process performance, availability, and quality are considered. From this impact, OEE-affecting factors are looked at. By reducing the losses associated with breakdowns and changeovers, which affect availability, and by reducing the losses associated with defects and setup scraps, which affect quality, OEE can be raised.
A Trick elimination of three OEE loss categories, such as Downtime Loss, Speed Loss, and Quality Loss, is necessary for a successful improvement of Overall Equipment Effectiveness (OEE). Employee buy-in and top management support are crucial for successful execution. It is essential to enhance the performance of the making systems in direction to increase productivity. High equipment obtainability, which is determined by equipment dependability and maintainability, is necessary to achieve the target production output. Although Overall Equipment Effectiveness (OEE) has been used extensively throughout the years, it is not a statistically meaningful metric. Overall equipment effectiveness (OEE) helps to categorise the areas for starting the equipment development but does not diagnose a specific cause for why a machine is not operating as capably as it might. Overall Equipment Effectiveness (OEE) is a structured process for constant enhancement that aims to maximize production effectiveness by classifying and eradicating losses related to production efficiency and equipment during the life cycle of the production system. This is done by actively involving team members from all stages of the operational pyramid in the process.

3. TPM PROCESSES

Planning and scheduling optimization is the main goal of TPM. The elements availability, performance, and yield also have an impact on productivity. Breakdowns and change-over or the scenario when the line is not running when it should be, cause availability losses. Speed reductions, brief stops, idle time, and unfilled positions all result in performance losses. Although the line may be operating in this instance, it is not producing as much as it should. Losses resulting from rejects and subpar product startup in the production line are included in yield losses. These losses result in low overall equipment effectiveness (OEE) values, which show how well the production process is working. TPM provides a structure to make it easier to assess these losses, which helps to increase the value of the OEE. The use of TPM results in both immediate and long-term gains. A linear organizational structure is necessary for TPM

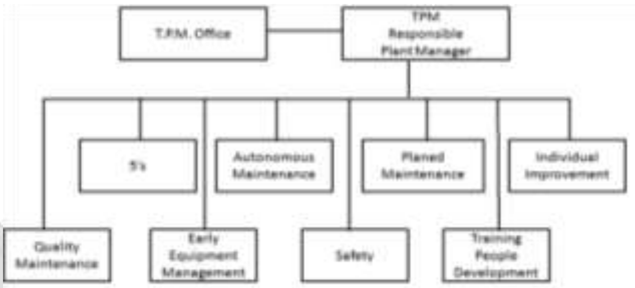

Figure 1 TPM Organizational Structure

Six Big Losses:

The Six Big Losses, which are the most frequent sources of efficiency loss in manufacturing, are one of the main objectives of OEE and TPM initiatives. The following table demonstrates the relationships between the OEE Loss categories and the Six Big Losses.

- Breakdowns:

To increase OEE, unplanned Down Time must be completely eliminated. If the process is broken, it is impossible to address other OEE factors. Knowing how much downtime your process is experiencing (and when) is vital, but it's also crucial to be able to link the lost time to a particular cause or source (tabulated through Reason Codes). With data on Down Time and Reason Code tallied. Starting with the types of losses that are the most severe, root cause analysis is used.

- Setup and Adjustments:

The time between the final quality component produced prior to setup and the first reliable quality component produced following setup is typically used to calculate setup and adjustment times. In order to continuously manufacture components that match quality standards, this frequently involves a significant amount of adjustment and/or warm-up time.

- Small Stops and Reduced Speed:

Of the Six Big Losses, Small Stops and Reduced Speed are the hardest to track and report. These loss types should be identified using Cycle Time Analysis. The majority of operations require automatic data logging because cycles are fast, recurring events that do not allow for enough time for human data collection.

- Startup Rejects and Production Rejects:

Production and Startup Rejections Rejects are distinct because startup and steady-state production frequently have different primary causes. Any parts that need to be reworked should be regarded as rejections. When rejects are tracked during a shift and/or task run, plausible causes can be identified, and frequently patterns are found.

Six big losses Category	OEE loss category	Event example	Comment
Breakdowns	Down Time Loss	• Tooling Failures •Unplanned Maintenance •General Breakdowns • Equipment Failure	There is flexibility on where to set the threshold between a Breakdown (Down Time Loss) and a Small Stop (Speed Loss).
Setup and Adjustments	Down Time Loss	• Setup/Changeover • Material Shortages • Operator Shortages • Major Adjustments • Warm-Up Time	This loss is often addressed through setup time reduction programs.
Small Stops	Speed Loss	• Obstructed Product Flow • Component Jams • Misfeeds • Sensor Blocked • Delivery Blocked • Cleaning/Checking	Typically, only includes stops that are under five minutes and that do not require maintenance personnel.
Reduced Speed	Speed Loss	• Rough Running • Under Nameplate Capacity • Under Design Capacity • Equipment Wear •Operator Inefficiency	Anything that keeps the process from running at its theoretical maximum speed (a.k.a. Ideal Run Rate or Nameplate Capacity).
Startup Rejects	Quality Loss	• Scrap • Rework • In-Process Damage • In-Process Expiration • Incorrect Assembly	Rejects during warm-up, startup or other early production. May be due to improper setup, warm-up period, etc.
Production Rejects	Quality Loss	• Scrap • Rework • In-Process Damage • In-Process Expiration • Incorrect Assembly	Rejects during steady-state production.

4. EXPERIMENTATION

Flanges are employed in a variety of industries, including gas, oil, transportation, and water. Additionally, it is utilized in chemical fertilizers, power generation, and chemicals. They are available in many forms and shapes. In addition, they have a variety of materials depending on the fluid type and service environment, such as stainless steel, low carbon steel, low alloy steel, non-ferrous steel, and high alloy steel. A flange is a device used to join valves, pipes, pumps, and other pieces of machinery to create a network of pipes. It offers accessibility for modifying, inspecting, or cleaning. They may be welded or screwed. Two flanges can be connected by using a certain type of seal. The flange is made up of Ductile iron and used in pipes. It is used as a coupling between two metal pipes. It is one of the parts of pipe fitting. Black heart malleable cast iron is used to make pipe fittings in accordance with IS 2108/currently IS: 14329-95.

The following are the key points of 212 cover

- Material: CI GI 4.0
- Unit weight of Casting: 1.2 kg

Melting

- Pouring Temperature: 1410℃– 1390℃
- Pouring Time: 6 to 7 sec

Physical Properties

- Hardness: 180 – 217 BHN
- Tensile strength: 260 N/mm2

Figure 2 Product Image

Calculation of Present Overall Equipment Efficiency (OEE)

The foremost pointer used to assess the effectiveness of the TPM implementation programme is OEE. TPM's overarching objective is to increase equipment effectiveness as a entire. OEE is computed by multiplying the product of equipment obtainability, process performance efficiency, and rate of high-quality product production. OEE is equivalent to the product of the three primary loss bases:

1. Problems with availability are those that result in downtime losses.

2. Performance represents the losses brought on by speed losses, and

3. Quality represents the losses brought on by scrap and rework.

OEE implementation process starts with measuring the existing OEE in machine shop for flange products. Six-month data from machine shop recorded and OEE for the collected data is calculated.
The following data shows the present Overall equipment effectiveness (OEE) calculation of VMC for the six months.
I) Month: March 2021
Availability:
Total working days in one month: 24 days
Total working hours in one month: 24 x 24 = 576hrs
Planned down time in one month: 42.5hrs
Total machine breakdown in month: 14.91hrs
Machine tool Set-up time: 25.16hrs
Overall set up and adjustment: 17.75hrs
Power off: 2.75hrs
Other (mis, cleaning): 12.41hrs
Loading time = Total available time –planned down time
=576 – 42.5 = 533.5hrs
Total loss time = machine breakdown time + set-up and adjustment + Machine tool set up + other
=82.31hrs
Net operating time = loading time – total loss time = 533 – 70.23 = 462.77hrs
Availability= (Net operating time)/(Loading time) x 100
= 84.5%
Performance rate:
Total no. of components produced in one time = 20504
Theoretical cycle time = 1.12 min.
Net operating time = 27070 min.
In actual practice the cycle time may be more than the theoretical because of some minor stoppages, speed reduction.
PE=(Total production numbers x Theoretical cycle time)/(Net operating time)
= 85.12 %
Quality Rate:
Total production numbers = 41228
Rejected parts = 8277
Accepted parts = 32951
QE= (Accepted parts)/ (Total produced parts) x 100
= 79.49 %
Overall equipment efficiency = Availability efficiency x performance efficiency x quality rate
= 84.5 x 85.12 x 79.49 =57.17 %
The following data shows present six-month data of OEE

Table 1: Existing Six Months Machine Shop OEE

Sr No.	*Month*	*Availability*	*Performance*	*Quality*	*OEE*
1	*21-Mar*	*84.5*	*85.12*	*79.49*	***57.17***
2	*21-Apr*	*88.14*	*83.31*	*81.07*	***59.53***
3	*21-May*	*85.79*	*83.33*	*81.88*	***58.54***
4	*21-June*	*87.37*	*84.75*	*83.78*	***62.04***
5	*21-July*	*86.93*	*86.35*	*82.78*	***62.14***
6	*21-Aug*	*88.32*	*82.68*	*85.13*	***62.16***
Average value		***86.84***	***84.26***	***82.36***	***60.26***

Execution of TPM Plan in Machine Shop
TPM plan is developed. It is thoroughly explained in above section. Now, it is the time of execute the plan. Different systematic efforts are required for the success of plan. This point deals with efforts were taken for stepwise implementation of plan.
Announcement of implementing TPM:
Top management was decided to implementation of TPM. It was formed and announced by the management. The notice was issued for employees. The meetings were arranged with all staff.

Arrangement of TPM education Programs:
Formally pronounce the assessment to Present TPM in organization by top management. The TPM project started with its campaigning and training in shop floor. During the training our main aim was to awareness about TPM. In the training participate were plant manager, various department engineers, supervisors and workers involved. The following list of participates were attended in the training. Total three training session were taken.
Implementation of 5 ‘S’:
5S is where TPM begins. The staff must be committed to honestly implementing and practicing housekeeping as part of a organized process of cleaning to create a calm workplace. The first step in solving problems is to make them evident. Since 5S was a foundation programme before TPM was implemented, it has been placed at the bottom. If 5S is not seriously implemented, 5D results. They are mistakes, mistakes, unhappy customers, falling profitability, and demoralized staff. These are the 5S's core values.

Focused Improvement

Eliminating Loss Due to Failure

Establish the fundamental conditions (clear, lubricate, tighten), maintain the fundamental operating conditions, restore all deteriorated functions to their original level, and strengthen the design flaws of the machinery were taken into consideration. Most of these points were covered in autonomous and preventive maintenance. Very fewer deficiencies were observed at this stage of implementation and necessary actions were taken to completely eliminate them. It decreases the losses due to failures.

Eliminating Loss Due to Defects and Rework

Study each of the causes individually was done concerned with defects and rework. It was found that there were almost zero defective parts during production machine. Some cases of rework were observed. Possible corrections were made to overcome the flaws for rework.

Preventive maintenance

During survey of existing system, TPM team found that company has good preventive maintenance schedule. It was also observed that activity is executed properly and consistently. The considered machines of machine shop were already the part of this procedure. During this step, team did not require more efforts to implement it. Only slight modifications were done in the schedule to enhance its effectiveness. The preventive maintenance schedule is given below.
The following month wise calculation represents the improved OEE after implementation of the TPM and 5S in machine shop.

I) Month: March 2022
A) AVAILABILTY:
Total working days in one month: 25 days
Total working hours in one month: 25 x 24 = 600hrs
Planned down time in one month: 44hrs
Total machine breakdown in month: 16.08 hrs
Machine tool Set-up time: 24.41hrs
Overall set up and adjustment: 14.58hrs
Power off: 2.91 hrs
Other (mis, cleaning): 21.5hrs
Loading time = Total available time –planned down time
=600 – 44 = 556hrs
Total loss time = machine breakdown time + set-up and adjustment + Machine tool set up + other =79.48hrs
Net operating time = loading time – total loss time = 556 – 79.48 = 476.5hrs
Availability=(Net operating time)/(Loading time) x 100
= 85.59%

B) Performance rate:
Total no. of components produced in one time = 22120
Theoretical cycle time = 1.12 min.
Net operating time = 28590 min.
In actual practice the cycle time may be more than the theoretical because of some minor stoppages, speed reduction.
PE=(Total production numbers x Theoretical cycle time)/(Net operating time)
= 86.77 %

C) Quality Rate:
Total production numbers = 43564
Rejected parts = 5716
Accepted parts = 37848
QE=(Accepted parts)/(Total produced parts) x 100
= 86.30 %

Overall equipment efficiency = Availability efficiency x performance efficiency x quality rate
= 85.59 x 86.77 x 86.30 =64.08 %

Table2: *Month wise Machine shop New OEE*

Sr No.	Month	Availability	Performance	Quality	OEE
1	22-March	85.58	86.77	86.3	64.08
2	22-April	87.05	86.38	86.02	64.68
3	22-May	89.36	84.13	85.35	64.16
4	22-June	87	85.25	86.07	63.84
Average value		87.25	85.63	85.94	64.19

5. RESULTS AND DISCUSSION:

Comparison of the Present and Improved OEE

A) Following table shows that comparison of the Present and improved OEE of the machine shop.

Table 3 Present and improved OEE of the machine shop

Sr. No	*Present Machining OEE (%)*	*Improved Machining OEE (%)*
1	*57.17*	*64.08*
2	*59.53*	*64.68*
3	*58.54*	*64.16*
4	*62.04*	*63.84*

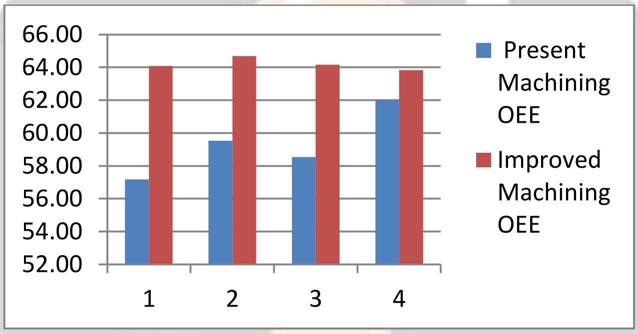

Figure 3 Present and improved OEE of the machine shop

It has been observed that due to the implementation of the new system Availability, Performance, Quality of the machine shop improved and total machine shop OEE increase by 4 %.

6. CONCLUSION

The output of the survey is different drawbacks and barriers which include less present OEE, absence of self-improvement of operator, firm resistance to change by operators, improper use of resources, and arrangement of tools and lack of regular maintenance activity. After study, it was decided to use TPM tools to improve the OEE. The TPM committee had worked on these things and came out with TPM plan. The activities were carried out for the successful execution of the plan. The comparison of new and previous system was done to decide the success of TPM. After implementation of the OEE there is significant change in the OEE of the foundry and OEE

Effect of different methodologies on various parameters are summarized below

- Implementation of 5S
- Autonomous maintenance
- Preventive Maintenance

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